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(54) **WATER TREATMENT FOR
HIGH-EFFICIENCY CLEANING**

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B01F 3/04 (2006.01)
B01F 5/04 (2006.01)

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C02F 2209/40 (2013.01); **C02F 2305/02**
(2013.01); **C02F 2307/12** (2013.01)

(58) **Field of Classification Search**
CPC **A47L 15/424**
See application file for complete search history.

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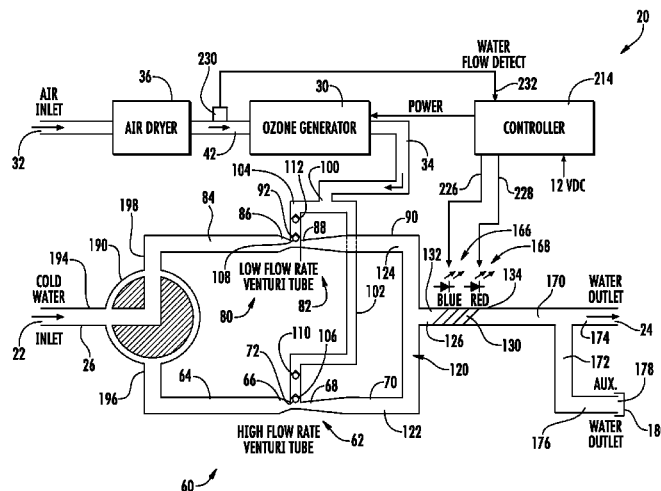
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(57) **ABSTRACT**

Water treatment apparatus for supplying ozonated water to appliances, such as clothes washing machines. First and second water aspirators include respective first and second Venturi tubes. One aspirator is designed for a relatively higher water flow rate, and the other is designed for a relatively lower water flow rate. A valve selectively directs water from a water inlet to a water outlet through either the first or the second water aspirator. Ozone from an ozone generator is drawn either into water flowing through the first Venturi tube or water flowing through the second Venturi tube, depending on the position of the valve. A water flow sensor includes a microphone physically connected for sensing a sound characteristic of operation of a Venturi tube. A controller effects a time delay for maintaining activation of the ozone generator for a predetermined time duration even after water flow has ceased.

6 Claims, 8 Drawing Sheets



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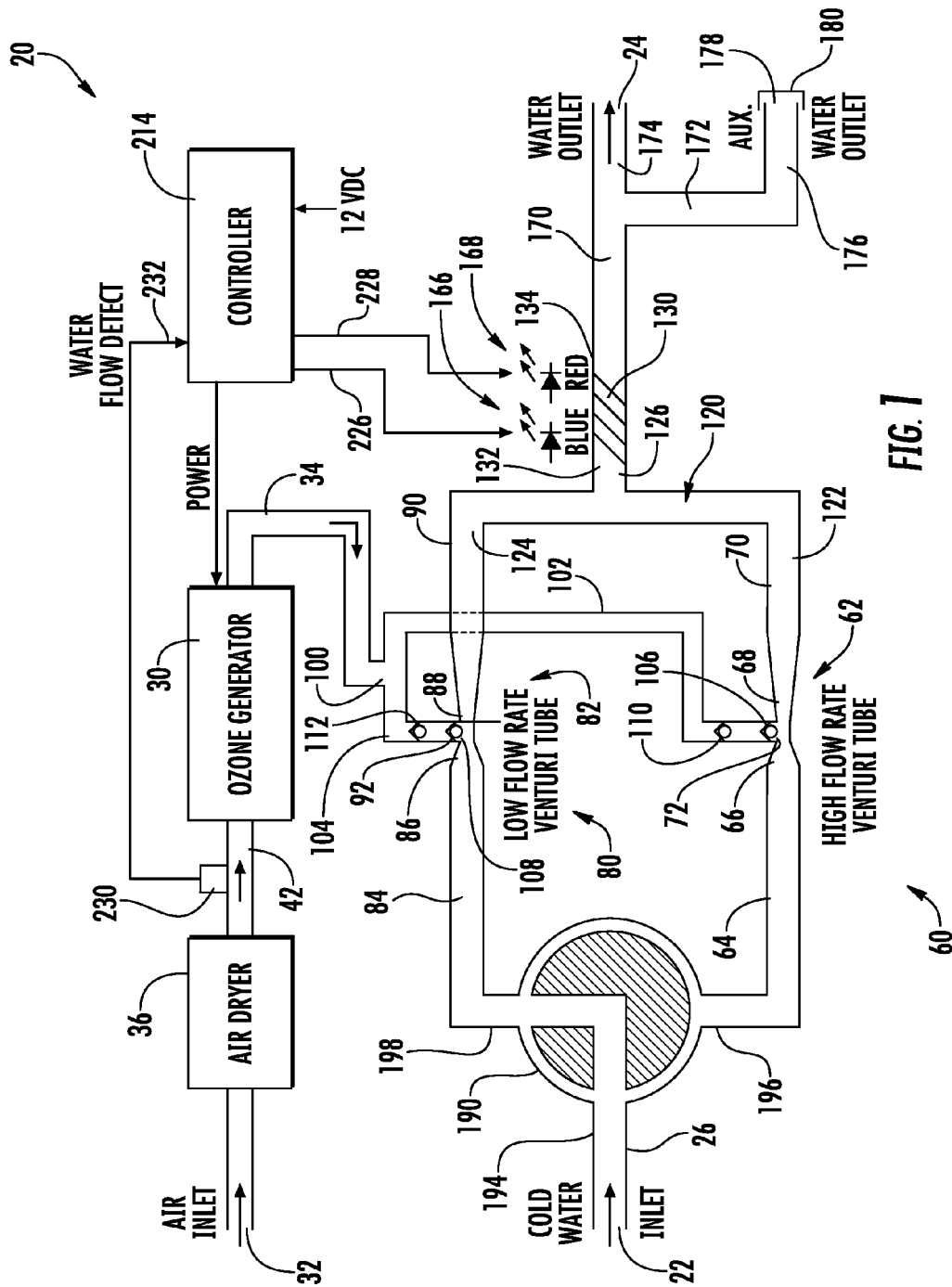
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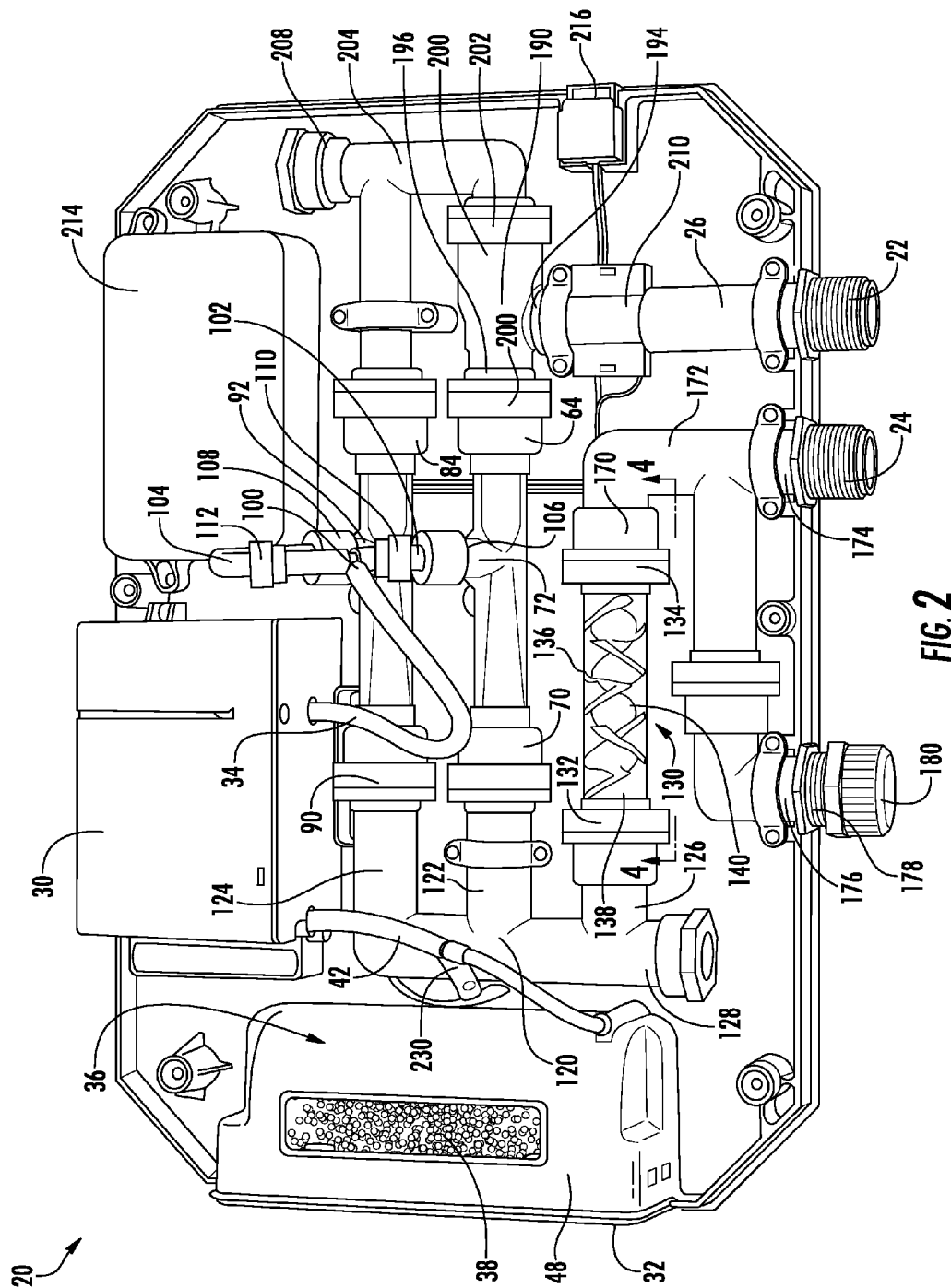
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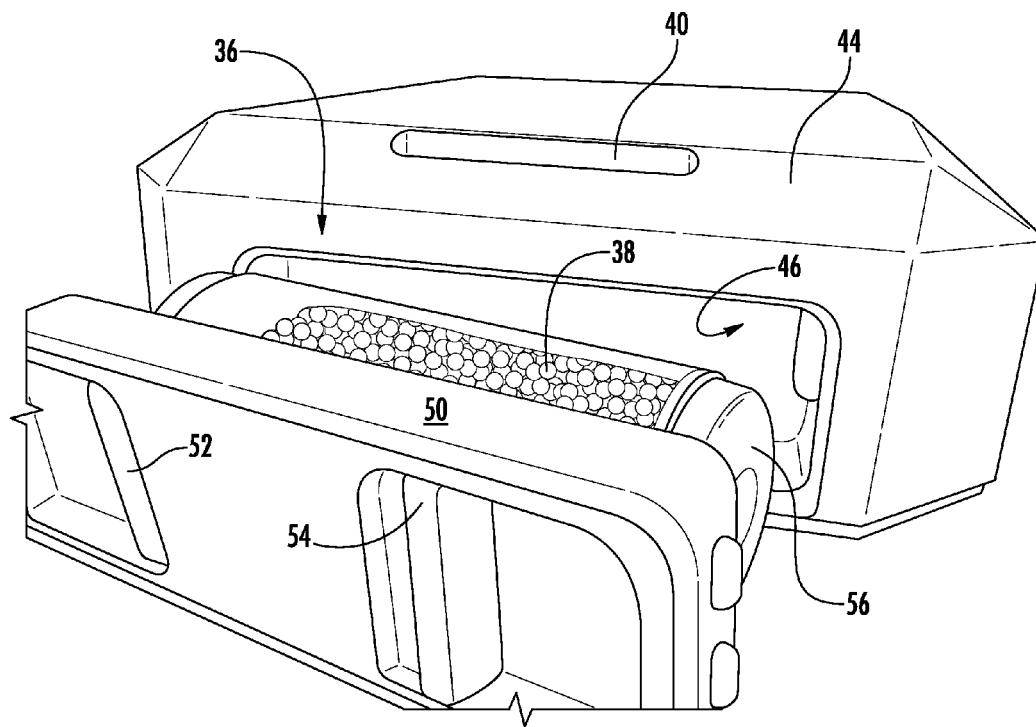


FIG. 3

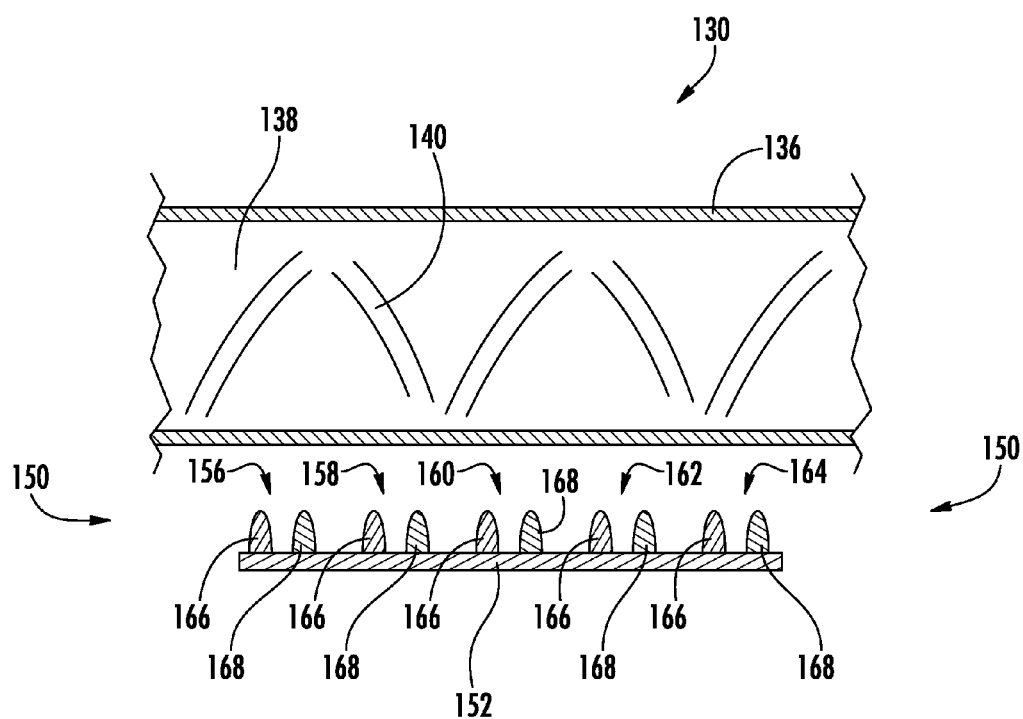


FIG. 4

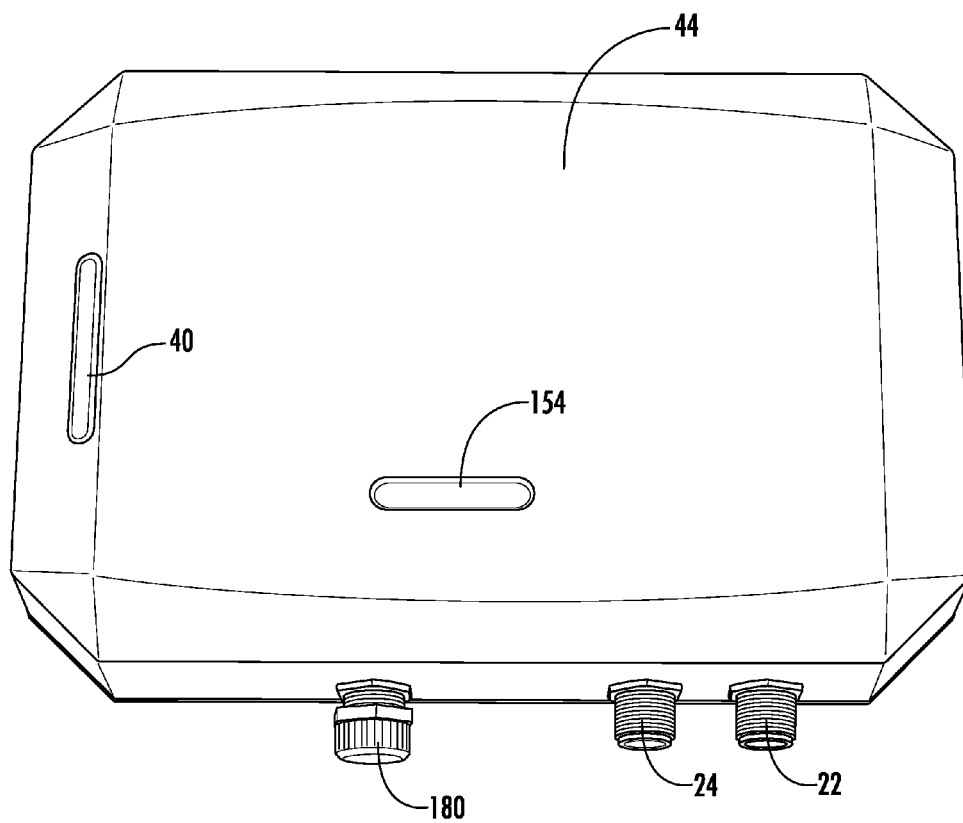


FIG. 5

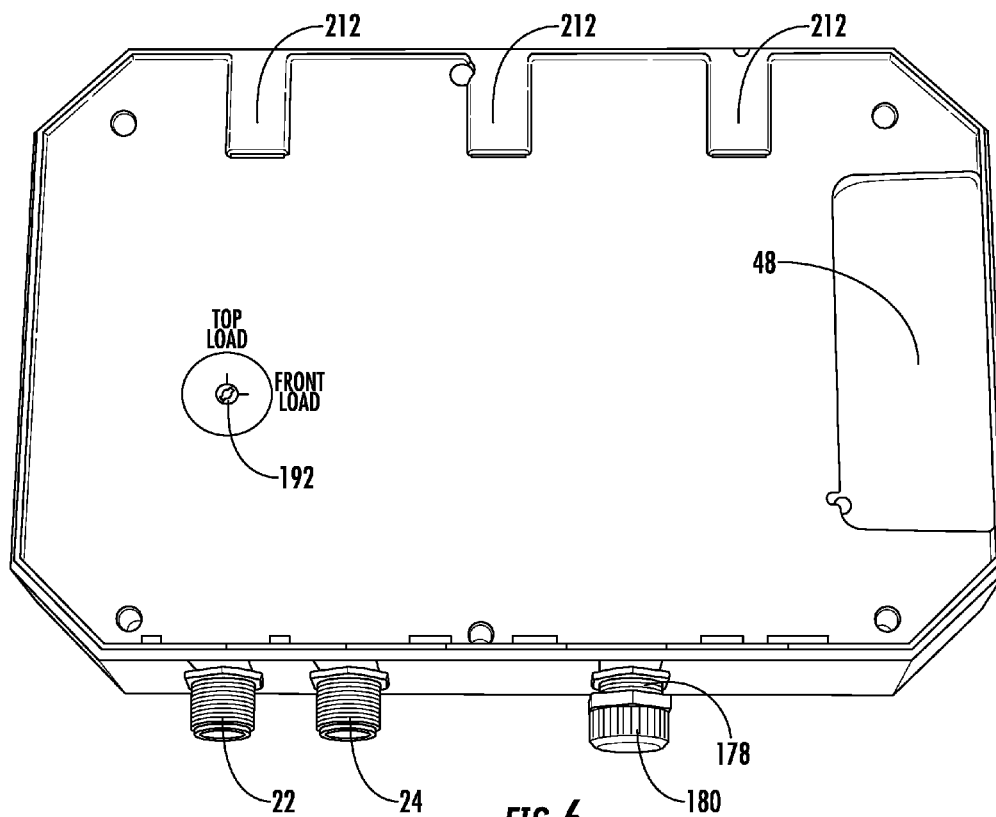


FIG. 6

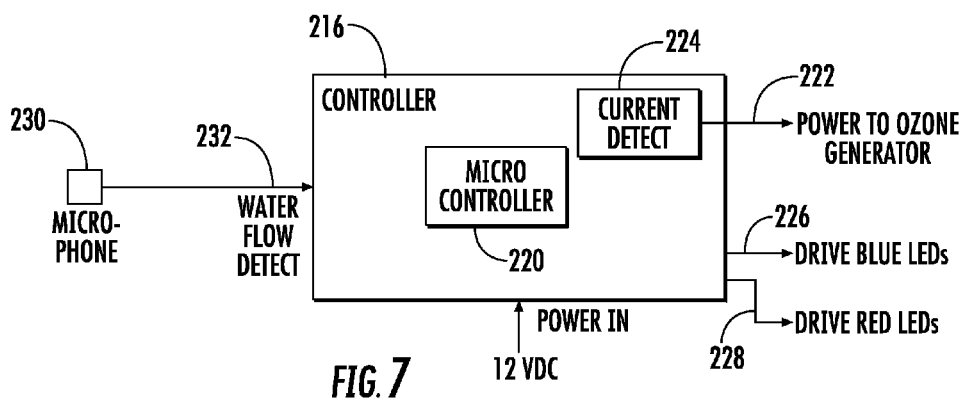


FIG. 7

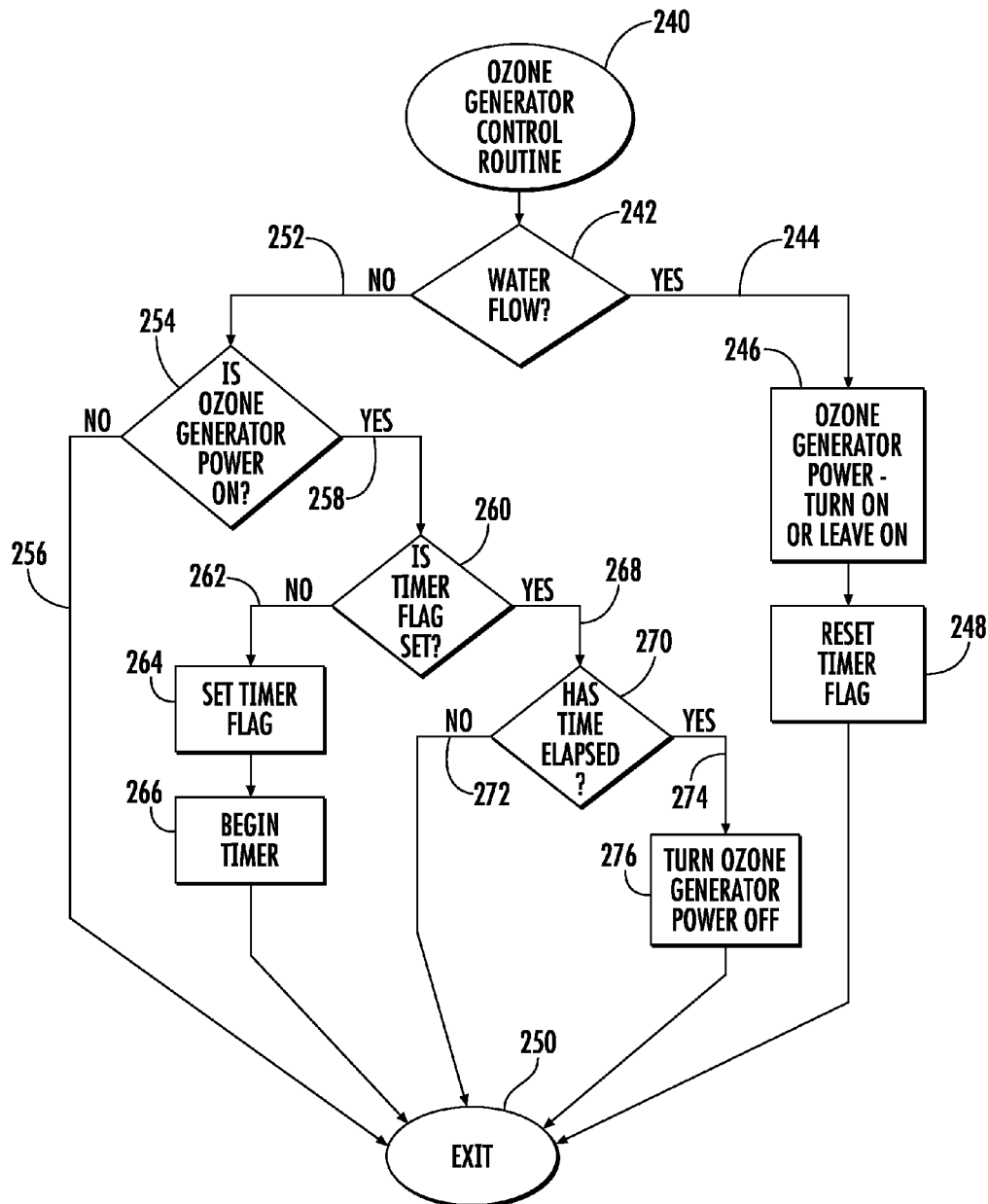
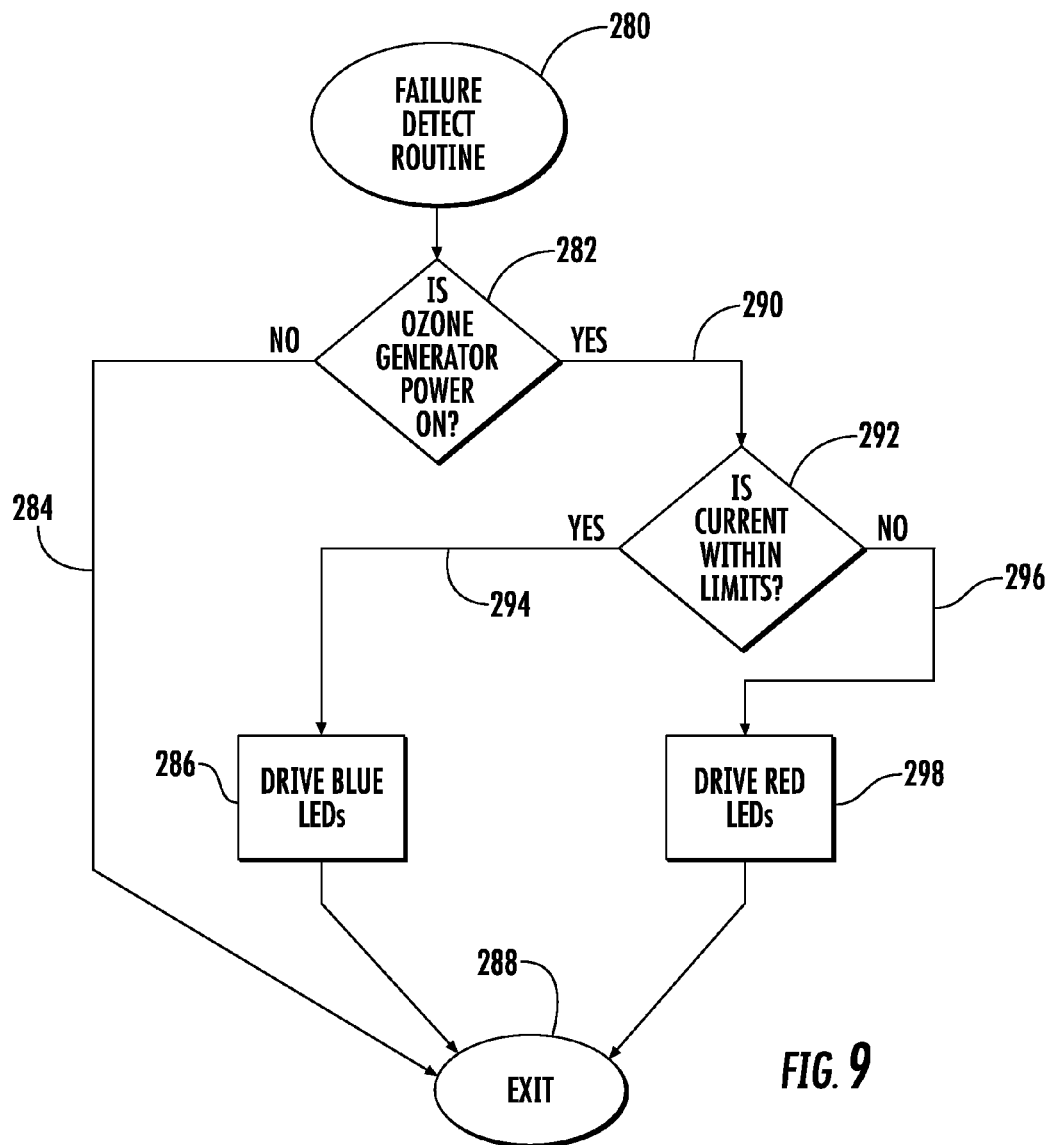


FIG. 8



WATER TREATMENT FOR HIGH-EFFICIENCY CLEANING

BACKGROUND OF THE INVENTION

Disclosed herein is an improvement of the embodiments described in Johnston U.S. patent application Ser. No. 13/898,095, filed May 20, 2013, and published as Pub. No. US 2013/0306569 on Nov. 21, 2013, the entire disclosure of which is hereby expressly incorporated by reference.

The invention relates to the treatment of water with ozone for supply to appliances, particularly clothes washing machines.

Ozone (chemical formula O_3) is well known as a powerful oxidant. A number of methods are known for producing ozone. Corona discharge is a common method, and is employed in embodiments of the invention disclosed herein. Another common method for generating ozone generator employs an ultraviolet light (UV). Other methods for generating ozone are a cold plasma method, and electrolytic ozone generation. Embodiments of the invention, however, are not limited to any particular type of ozone generator. It is also well known that ozone can be dissolved in water, and also can exist as small bubbles in water, both of which are known as ozonated water.

The use of ozonated water in a clothes washing machine has a number of advantages. As examples, the use of detergent can be reduced or eliminated. As a result, expense for detergent is reduced or eliminated, as well as build up of detergent residue. (Related to the reduction or elimination of detergent, the wastewater from a clothes washing machine supplied with ozonated water is considered "green," without high levels of biological oxygen demand (BOD) food for bacteria.) Cold water can be used for clothes washing, providing energy savings from reduced hot water usage. The life of clothing, as well as the life of a washing machine, can be extended.

Ozonated water used in a clothes washing machine can remove irritating chemicals from clothing. This is particularly important for persons with chemical sensitivity.

In addition, ozonated water significantly reduces microbes, including mold, bacteria and viruses.

SUMMARY OF THE INVENTION

In one aspect, water treatment apparatus is provided. The water treatment apparatus has a water inlet and a water outlet, as well as first and a second water aspirators including respective first and second Venturi tubes through which water can flow. Each of the Venturi tubes has a water inlet port, a water outlet port, and a vacuum port. The first Venturi tube is designed for a relatively higher water flow rate and the second Venturi tube is designed for a relatively lower water flow rate. The water treatment apparatus also has a valve with two positions for selectively directing water from the water inlet to the water outlet through either the first or the second water aspirator. An ozone generator has an output connected to the vacuum ports. As a result, gas including ozone is drawn either into water flowing through the first Venturi tube or water flowing through the second Venturi tube, depending on the position of the valve.

In another aspect, water treatment apparatus is provided. The water treatment apparatus has a water inlet and a water outlet, as well as at least one water aspirator including a Venturi tube through which water can flow. The Venturi tube has a water inlet port, a water outlet port, and a vacuum port. An ozone generator has an output connected to the vacuum port. As a result, gas including ozone is drawn into water

flowing through the Venturi tube. A water flow sensor includes a microphone physically connected for sensing a sound characteristic of operation of the Venturi tube. The water flow sensor is connected to a controller for activating the ozone generator when water is drawn out of the water outlet and thereby through the at least one water aspirator.

In yet another aspect, water treatment apparatus is provided. The water treatment apparatus has a water inlet and a water outlet, as well as at least one water aspirator including a Venturi tube through which water can flow. The Venturi tube has a water inlet port, a water outlet port, and a vacuum port. An ozone generator has an output connected to the vacuum port. As a result, gas including ozone is drawn into water flowing through the Venturi tube. A water flow sensor is connected to a controller for activating the ozone generator when water is drawn out of the water outlet and thereby through the at least one water aspirator. The controller effects a time delay for maintaining activation of the ozone generator for a predetermined time duration even after water flow as sensed by the water flow sensor has ceased. As a result, the ozone generator operates continuously when water is intermittently drawn out of the water outlet.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of water treatment apparatus embodying the invention;

FIG. 2 is a three dimensional view, showing an exemplary mechanical layout within the interior of the water treatment apparatus shown schematically in FIG. 1;

FIG. 3 is a three dimensional left side view of the water treatment apparatus, showing an air dryer employing a desiccant;

FIG. 4 is a view taken on line 4-4 of FIG. 2, showing LEDs which illuminate a mixer within the water treatment apparatus;

FIG. 5 is a three-dimensional top view of the water treatment apparatus showing a window through the mixer is observed, as well as LED color;

FIG. 6 is a three-dimensional rear view of the water treatment apparatus, showing a control for a two-position valve employed during initial setup of the apparatus;

FIG. 7 is a highly schematic representation of a controller, which in turn includes a microcontroller, within the water treatment apparatus of FIGS. 1 and 2;

FIG. 8 is a flow chart of an "Ozone Generator Control Routine" that runs within the microcontroller; and

FIG. 9 is a flowchart of a "Failure Detect Routine" that also runs within the microcontroller.

DETAILED DESCRIPTION

With reference to both the schematic diagram of FIG. 1 and the exemplary mechanical layout of FIG. 2, water treatment apparatus 20 embodying the invention includes a water inlet 22 for connection, as an example, to a domestic cold water supply, as well as a water outlet 24 for connection, as an example, to the cold water inlet of a domestic clothes washing machine. Within the apparatus 20, the water inlet 22 is connected to a water outlet 24. The apparatus 20 functions to ozonate water supplied to the water inlet 22 and delivered at the water outlet 24.

Accordingly, the apparatus 20 additionally includes an ozone generator, generally designated 30, and an air inlet 32, which receives ambient air. Ozone generators are well known. In the particular embodiment disclosed herein, the ozone generator 30 employs corona discharge. Accordingly,

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the corona discharge ozone generator **30** employs a high voltage power supply (not shown) which generates a voltage applied across glass dielectric plates (not shown) to develop a corona discharge, which then produces ozone from oxygen in the ambient air. Venturi tube vacuum, described in greater

Corona discharge ozone generators function better when supplied with relatively drier air. An air dryer generally designated **36** is included. In the disclosed embodiment, the air dryer **36** employs a desiccant **38** including silica gel. The desiccant **38** changes color from blue when new, to pink when the desiccant **38** requires replacement, and is visible through a window **40** (FIG. 3). Relatively dryer air accordingly is supplied from the air dryer **36** to the ozone generator **30** via an inlet air conduit **42**.

Referring briefly to FIG. 3, which is a side view of the water treatment apparatus **20** with a top cover **44** in place, the air dryer **36** includes a cavity **46** (FIG. 3) within a cavity body **48** (FIG. 2) which receives a holder **50**. The holder **50** has two latch actuators **52** and **54**, and supports a removable and replaceable desiccant cartridge **56**. The desiccant cartridge **56** contains the actual desiccant **38**. The window **40**, through which the color of the desiccant **38** is observed, is in the top cover **44**.

Relatively dry air exits the desiccant cartridge **56** at the right side in the orientation of FIG. 3, to enter the inlet air conduit **42**. Ambient air enters the cavity **46** and then the desiccant cartridge **56** from outside the apparatus through cracks or small openings between the holder **60** and the cavity body **48**. The holder **50** thus does not have a tight fit.

Referring again to FIGS. 1 and 2, cold water flows from the water inlet **22** to the water outlet **24** through at least one water aspirator, generally designated **60**. The water aspirator **60** includes a conventional Venturi tube **62** which has a water inlet port **64**, an inlet cone **66** with a relatively greater angle, an outlet cone **68** with a relatively shallower angle, and a water outlet port **70**. As a result of increased water velocity immediately downstream of the inlet cone **66**, a vacuum is generated at a vacuum port **72**, which is employed to draw a gaseous mixture of air and ozone into water flowing through the aspirator **60**.

In the disclosed embodiment, there are two water aspirators, including respective first and second Venturi tubes. Thus, the aspirator **60** and its respective Venturi tube **62** are herein termed the first aspirator **60** and the first Venturi tube **62**.

A second water aspirator **80** includes a corresponding Venturi tube **82**, likewise having a water inlet port **84**, an inlet cone **86** with a relatively greater angle, an outlet cone **88** with a relatively shallower angle, a water outlet port **90**, and a vacuum port **92**.

The outlet air conduit **34** of the ozone generator **30** branches, at a "Y" connection **100**, into two separate conduits **102** and **104**. To ensure that water does not flow from the Venturi tubes **62** and **82** back into the ozone generator **30** via the conduits **102** and **104** and the outlet air conduit **34**, several check valves are provided. In particular, at the two vacuum ports **72** and **92** are a corresponding pair of primary check valves **106** and **108**. In addition, secondary check valves **110** and **112** are provided in the two conduits **102** and **104**.

A particular problem addressed by some embodiments of the invention is that different clothes washing machines have different water flow rates when filling. For example, a top load washer may require as much as forty gallons of water per load to fill, and fills at a relatively higher water flow rate. A front load washer requires typically fourteen gallons of water

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per load to fill, and typically fills at a relatively lower water flow rate. This difference in water fill rates has two consequences. First, a Venturi tube is designed for a particular minimum water flow rate threshold, below which the Venturi tube loses effect and essentially does not function. As a result, a Venturi tube designed for a top load washer with a relatively higher water fill rate may not function at all with a front load washer which draws water at a relatively lower fill rate. Second, if a Venturi tube is designed for the relatively lower fill rate of a front load washer, the Venturi tube does function at the relatively higher fill rate of a top load washer. The overall fill time is increased. The concentration of ozone is reduced, reducing the effectiveness of the ozonization during the actual agitation portion of a washing machine cycle.

In water treatment apparatus available to the prior invention, different models were available. A customer selected one model or the other depending on the type of washing machine.

Addressing this particular problem in a different way, the illustrated embodiment of the invention employs the first and the second water aspirators **60** and **80**, including respective first and second Venturi tubes **62** and **82**, which are designed for different flow rates. By way of example and not limitation, the first water aspirator **60** and Venturi tube **62** are designed for a relatively higher water flow rate of 2.3 gallons per minute. By way of example and not limitation, the second water aspirator **80** and Venturi tube **82** are designed for a relatively lower water flow rate of 1.3 gallons per minute. 2.3 gallons per minute is slightly less than the typical water fill rate of a top load washer, and 1.3 gallons per minute is slightly less than the typical water fill rate of a front load washer.

Downstream of the water aspirators **60** and **80** is an outlet manifold **120** having two inlets **122** and **124** connected to the two Venturi tube outlet ports **70** and **90**, respectively. The outlet manifold **120** has a manifold outlet **126** which is connected to a mixer, generally designated **130**. The mixer **130** accordingly is downstream of the two water aspirators **60** and **80**. The outlet manifold **120** is a molded plastic piece, and has a capped extension **128**, which is an artifact of the molding process.

In the illustrated embodiment, the mixer **130** includes a mixer input port **132** connected to the manifold outlet **126**, as well as a mixer output port **134**. The mixer **130** more particularly takes the form of a transparent outer tube **136** and a spiraled inner chamber **138** defined by a stationary helix **140**. Within the mixer **130**, gas (a mixture of air and ozone) is mixed and at least partially dissolved in water flowing through the apparatus **20** and being treated. During normal operation, bubbles are visible within the mixer **130** through the transparent tube **136**.

Referring briefly to FIG. 4, to facilitate viewing of bubbles within the mixer **130**, illumination is provided, as well as operational status of the apparatus **20** indicated, by a set of LEDs **150**, supported on a circuit board **152** mounted underneath the transparent outer tube **136**. Referring to FIG. 5, in addition to FIG. 4, a window **154** is provided in the top cover **44** for viewing the status LEDs **150**, as well as the bubbles within the mixer **130**.

The LEDs **150** more particularly are organized as five LED pairs **156**, **158**, **160**, **162** and **164**. Each of the pairs includes a blue LED **166** and a red LED **168**. As described in greater detail hereinbelow, the blue LEDs **166** are energized to indicate normal operation, and the red LEDs **168** are energized to indicate a fault condition.

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Referring again to FIGS. 1 and 2, connected to the mixer output port 134 is an input port 170 of a discharge manifold 172. The discharge manifold 172 has two output ports 174 and 176.

The output port 174 is the main output port, and corresponds to the water outlet 24 of the water treatment apparatus 20, which water outlet 24 may be viewed as the main water outlet. The outlet port 176 corresponds to a secondary water outlet 178, which has a cap 180. The secondary water outlet 178 is provided in the event the water treatment apparatus 20 is to be used to provide ozonated water to something other than a washing machine connected to the main water outlet 24. The water inlet 22, the main water outlet 24, and the secondary water outlet 178 all have threaded hose connections for apparatus 20 intended to be sold in the United States.

For selectively directing water from the water inlet 22 to the water outlet 24, a single two-position valve 190 having three ports is provided. With reference to the rear view of FIG. 6, the valve 190 is operated via a slotted actuator 192 during initial setup employing, for example, an ordinary screwdriver.

In the illustrated embodiment, the valve 190 is connected to the input end of the water aspirators 60 and 80. In other words, the valve 190 selectively connects the water inlet 22 to either the water inlet port 64 of the first Venturi tube 62 or the water inlet port 84 of the second Venturi tube 82. More particularly, the valve 190 has an inlet port 194 connected to and supplied with water via the water inlet tube 26, a first outlet port 196 connected to the water inlet port 84 of the second Venturi tube 82 via a coupler 198, and a second outlet port 200 connected via a coupler 202 to a "U" tube 204. The "U" tube 204 is in turn connected via a coupler 206 to the water inlet port 64 of the first Venturi tube 62. The "U" tube 204 is a molded plastic piece and, like the discharge manifold 172, has a capped extension 208 which is an artifact of the molding process.

It will, however, be appreciated that the function of selectively directing water from the water inlet 22 to the water outlet 24 through either of the water aspirators 60 and 80 can as well be accomplished by providing a valve (not shown) at the outlet ends of the two Venturi tubes 62 and 80, and providing a simple manifold (not shown) at the input of the two Venturi tubes 62 and 82.

In any event, during initial installation of the water treatment apparatus 20, the valve 190 is set, employing the slotted actuator 192 (FIG. 6), to direct water through either the first water aspirator 60 and Venturi tube 62, or the second water aspirator 80 and Venturi tube 82, depending upon the type of washing machine connected or to be connected to draw water from the water outlet 24. Again, in the case of a top load washer, which has a relatively higher water fill rate, the valve 190 is set to direct water flow through the first water aspirator 60 and Venturi tube 62 ("TOP LOAD" position). In the case of a front load washer, having a relatively lower water fill rate, the valve 190 is set to direct water through the second water aspirator 80 and the second Venturi tube 82 ("FRONT LOAD" position).

Also visible in FIG. 6 are the underside of the cavity body 48 of the air dryer 36, as well as three hanger slots 212.

In addition to the primary functional components described hereinabove, several additional components are shown in FIGS. 1 and 2.

For additional water conditioning, a magnetic water ionizer/descaler 210 is connected to the water inlet tube 26, immediately downstream of the water inlet 24. A controller, generally designated 214, controls the ozone generator 30, as well as the blue and red LEDs 166 and 168. The controller 214, in the illustrated embodiment, operates from 12 Volts

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DC, provided by an external power supply (not shown) connected via a power input connector 216 (FIG. 2).

Referring now to FIG. 7, the controller 214 is supplied with 12 Volt D.C. power, and includes a printed circuit board (not shown) supporting a microcontroller 220. The microcontroller 220 is programmed to effect various control functions, including functions represented by an "Ozone Generator Control Routine" represented by the flowchart of FIG. 8, and a "Failure Detect Routine" represented in the flowchart of FIG. 9. The controller 214 in general, and the microcontroller 220 in particular, control D.C. power provided to the ozone generator 30 via an output 222. (The ozone generator 30 includes a conventional high voltage generator (not shown) which operates from 12 Volts D.C.) A current detector 224 measures current drawn by the ozone generator 30. The controller 214 also includes outputs 226 and 228 for driving the BLUE 166 and RED 168 LEDs, respectively.

An aspect of the disclosed embodiment is the manner in which water flow is detected. In general (but with an exception described hereinbelow with reference to FIG. 8), the ozone generator 30 is not supplied with power unless the washing machine is drawing water through the water outlet 24. At other times, and in general, the ozone generator 30 is not energized.

Water flow is detected employing a microphone 230, and associated control routines within the microcontroller 220, which recognize a characteristic sound when water is being drawn and either of the two Venturi tubes 62 or 82 is operating. In the disclosed embodiment, a relatively simple approach is employed: When a sound having a frequency over 10 Hz is detected, it is assumed that one of the Venturi tubes 62 or 82 is operating. A suitable microphone 230 is a Panasonic Model WM-60A electret condenser microphone.

To avoid possible corrosive effects of ozonated water, the microphone at 230 is connected to the inlet air conduit 42. Although this particular location is somewhat removed from the Venturi tubes 62 and 82, the characteristic sound travels through the apparatus 26, in particular through the air outlet conduit 34 and the ozone generator 30, and effectively reaches the microphone 230.

Microphone 230 output is connected to a water flow detect input 232 of the controller 214, and thereby to the microcontroller 220.

Another aspect of the disclosed embodiment addresses the situation whereby, in many washing machines, at particular times during a washing machine cycle, water flow is pulsed ON and OFF briefly, for example five, ten or fifteen seconds at a time. Under such conditions, it is preferable for the ozone generator 30 to operate continuously, rather than for brief intervals. Thus, when the water stops flowing, the microcontroller 230 implements a timer, which allows the ozone generator 30 to remain powered ON for one minute, for example, before turning OFF.

There are two reasons for this. One reason is that ozone generation is not immediate; it may take several seconds for ozone to be generated after the ozone generator 30 is powered ON. Another reason is that the life of the ozone generator 30 is extended if the ozone generator 30 is allowed to operate continuously during such periods when water is drawn intermittently by the washing machine in a pulsed manner.

Accordingly, and with particular reference to the Ozone Generator Control Routine 240 of FIG. 8, decision box 242 determines whether water is flowing, again, via the detection (or not) of the characteristic sound of a Venturi tube operating. If water is flowing, then YES decision branch 244 is taken.

In box 246, power to the ozone generator 30 is turned ON or, if already ON, is left ON. In box 248, a TIMER FLAG is

RESET. Thus, during portions of a washing machine cycle when water is drawn in intermittent pluses, the exemplary one-minute timer is reset each time water is drawn. The routine then exits at **250**.

If water is not flowing, then NO branch **252** is taken from decision box **242**.

Then, in decision box **254**, it is determined whether the ozone generator **30** is powered. If not, then NO branch **256** is taken, to exit at **250**. If the ozone generator power is ON, then YES branch **258** is taken. Decision box **260** then determines whether the TIMER FLAG is SET. If not, meaning water has just stopped being drawn from the outlet **24**, NO branch **262** is taken. In box **264**, the TIMER FLAG is SET. In box **266** a timer is started, by way of example, a one-minute timer. The routine then exits at **250**.

If in decision box **260** it is determined that the TIMER FLAG is already SET, meaning water has recently stopped being drawn from the outlet **24** ("recently" meaning less than one minute prior), then YES branch **268** is taken.

Another decision box **270** then checks the timer to determine whether the exemplary one-minute time has elapsed. If not, then NO branch **272** is taken, and the routine then exits at **250**.

If the exemplary one-minute time has elapsed, then YES branch **274** is taken. In box **276**, power to the ozone generator **30** is turned OFF. The routine then exits at **250**.

As another aspect of the disclosed embodiment, the current detector **224** is employed to determine whether the ozone generator **30** is operating properly. During normal operation, current drawn by the ozone generator **30** is within the approximate range 0.8 amperes to 2.0 amperes. If current drawn by the ozone generator **30** is above a predetermined maximum value, for example above 2.0 amperes, or below a predetermined minimum value, for example below 0.8 amperes, such indicates that the ozone generator **30** has failed.

If the ozone generator is operating normally (regardless of whether water is currently flowing), then normal operation is indicated, and the blue LEDs **166** are operated. If, on the other hand, current drawn by the ozone generator is above the predetermined maximum value (2.0 amperes in the illustrated embodiment) or below the predetermined maximum value (0.8 amperes in the illustrated embodiment), then the red LEDs **168** are operated, indicating to a customer that a failure has occurred. To particularly draw attention, the red LEDs **168** may be operated in a flashing manner.

With particular reference to an ozone generator Failure Detect Routine **280** of FIG. 9, in decision box **282** it is determined whether the ozone generator **30** is powered ON. If not, then NO branch **284** is taken, and the routine exits at **288**.

If in decision box **282** it is determined that the ozone generator **30** is powered ON, then YES branch **290** is taken, and execution passes to decision box **292**. If in decision box **292** it is determined that current, as detected by the current detector **224** is within the predetermined limits, then YES branch **294** is taken, to box **286**, where the BLUE LEDs **166** are driven.

If, on the other hand, in decision box **292** it is determined that current is not within limits, then NO branch **296** is taken.

In box **298** the RED LEDs **168** are driven. To particularly draw attention, the red LEDs **168** may be driven to flash. The routine then exits at **288**.

While a specific embodiment of the invention has been illustrated and described herein, it is realized that numerous modifications and changes will occur to those skilled in the art. It is therefore to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit and scope of the invention.

What is claimed is:

1. Water treatment apparatus comprising:

a water inlet;

a water outlet;

first and second water aspirators including respective first and second Venturi tubes through which water can flow, each of said Venturi tubes having a water inlet port, a water outlet port, and a vacuum port, said first Venturi tube being designed for a relatively higher water flow rate and said second Venturi tube being designed for a relatively lower water flow rate, the two Venturi tubes having different minimum water flow rate thresholds, below which the respective Venturi tube will not function;

a single three-port valve having two positions for selectively directing water from said water inlet to said water outlet through either said first or said second water aspirator; and

an ozone generator having an output connected to said vacuum ports, whereby gas including ozone is drawn either into water flowing through said first Venturi tube or water flowing through said second Venturi tube, depending on the position of said valve.

2. The water treatment apparatus of claim 1, wherein said valve selectively connects said water inlet to said water inlet port of either said first or said second water aspirator.

3. The water treatment apparatus of claim 1, which further comprises a mixer downstream of said water aspirators for facilitating the dissolving of ozone into water which has flowed through said first Venturi tube or water which has flowed through said second Venturi tube, depending on the position of said valve.

4. The water treatment apparatus of claim 1, which further comprises a water flow sensor connected to a controller for activating said ozone generator when water is drawn out of said water outlet and thereby through either said first or said second water aspirator.

5. The water treatment apparatus of claim 4, wherein said water flow sensor includes a microphone physically connected for sensing a sound characteristic of operation of a Venturi tube.

6. The water treatment apparatus of claim 4, wherein said controller effects a time delay for maintaining activation of said ozone generator for a predetermined time duration even after water flow as sensed by said water flow sensor has ceased, whereby said ozone generator operates continuously when water is intermittently drawn out of said water outlet.

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